

3,3'-DIMETHOXYBENZIDINE AND DYES METABOLIZED TO 3,3'-DIMETHOXYBENZIDINE

INTRODUCTION

3,3'-Dimethoxybenzidine was first listed in the *Third Annual Report on Carcinogens* (RoC) in 1983. 3,3'-Dimethoxybenzidine-based dyes that are metabolized to 3,3'-dimethoxybenzidine (3,3'-Dimethoxybenzidine Dyes Class) were first listed in the *Tenth Edition of the RoC* in 2002.

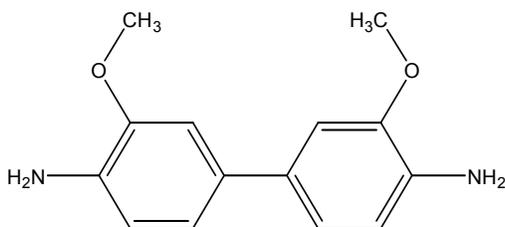
The profiles for 3,3'-dimethoxybenzidine and dyes metabolized to 3,3'-dimethoxybenzidine follow this introduction. The listings for 3,3'-dimethoxybenzidine and dyes metabolized to 3,3'-dimethoxybenzidine in the RoC are as follows:

- 3,3'-Dimethoxybenzidine is *reasonably anticipated to be a human carcinogen* based on sufficient evidence of carcinogenicity from studies in experimental animals, which indicates there is an increased incidence of malignant and/or a combination of malignant and benign tumors at multiple tissue sites in rats (IARC 1974, NTP 1990, 1998).
- 3,3'-Dimethoxybenzidine dyes that are metabolized to 3,3'-dimethoxybenzidine are *reasonably anticipated to be human carcinogens* based on the fact that 3,3'-dimethoxybenzidine is *reasonably anticipated to be a human carcinogen* (NTP 2000) and the fact that these compounds have the same type of chemical bond (azo linkages), which is easily broken by chemical or enzymatic reduction to form free 3,3'-dimethoxybenzidine and the respective chromophore(s). The metabolism of 3,3'-dimethoxybenzidine-based dyes to release free 3,3'-dimethoxybenzidine is a generalized phenomenon that occurs in all animal species studied (Lynn *et al.* 1980, Bowman *et al.* 1982).

3,3'-DIMETHOXYBENZIDINE

CAS No. 119-90-4

First listed in the *Third Annual Report on Carcinogens*



CARCINOGENICITY

3,3'-Dimethoxybenzidine is *reasonably anticipated to be a human carcinogen* based on sufficient evidence of carcinogenicity from studies in experimental animals, which indicates there is an increased incidence of malignant and/or a combination of malignant and benign tumors at multiple organ sites in rats (IARC 1974, NTP 1990, 1998). When given by stomach intubation to both male and female rats, 3,3'-dimethoxybenzidine caused tumors at various sites, including Zymbal gland tumors and cancer of the intestine (carcinoma), skin (carcinoma), and urinary bladder (papilloma). When given to rats in the diet, 3,3'-dimethoxybenzidine increased the incidence of cancer in the forestomach (papilloma). When the dihydrochloride salt of 3,3'-dimethoxybenzidine was administered in the drinking water to male and female rats, increased incidences of Zymbal gland cancer (adenoma and carcinoma), liver neoplasms and cancer (neoplastic nodules and hepatocellular carcinoma), cancer of the large intestine (adenomatous polyps and adenocarcinoma), skin cancer (basal-cell adenoma and carcinoma), and cancer of the oral cavity (squamous-cell papilloma and carcinoma) were observed. Male rats also had increased incidences of preputial gland carcinoma, cancer of the small intestine (adenocarcinoma), and mesothelioma, and female rats had increased incidences of cancer of the clitoral gland (adenoma and carcinoma), mammary gland (adenocarcinoma), and uterus or cervix (adenoma and carcinoma) (NTP 1990).

No adequate human studies of the relationship between exposure to 3,3'-dimethoxybenzidine and human cancer have been reported. No epidemiological studies have been published on cancer in workers exposed only to 3,3'-dimethoxybenzidine. Most of the workers exposed to this substance also were exposed to benzidine or other related amines, which are strongly associated with urinary bladder cancer in humans (IARC 1974, 1982, 1987).

PROPERTIES

3,3'-Dimethoxybenzidine, also known as *o*-dianisidine, is a colorless crystalline (sand-like) material that may turn violet upon standing. It is used in the production of dyes and is sensitive to heat, air, and prolonged exposure to light. 3,3'-Dimethoxybenzidine is slightly soluble in water and 95% ethanol and soluble in dimethylsulfoxide, acetone, benzene, ether, and chloroform (NTP 2001). 3,3'-Dimethoxybenzidine is available commercially as the free base (technical and 99% grades) and as its dihydrochloride salt (HSDB 2001).

USE

3,3'-Dimethoxybenzidine is used almost exclusively as a chemical intermediate for producing dyes and pigments. The Society of Dyers and Colourists reported its use in the production of 89 dyes in 1971, including Direct Blue 218, pigment orange 16, Direct Blue 1, Direct Blue 15, Direct Blue 8, Direct Blue 76, and Direct Blue 98. Some 3,3'-dimethoxybenzidine is used as a chemical intermediate to produce *o*-dianisidine diisocyanate for use in adhesives and as a component of polyurethanes. 3,3'-Dimethoxybenzidine is used as a dye for leather, paper, plastics, rubber, and textiles, and as a test substance to detect metals, thiocyanates, and nitrites (IARC 1974, HSDB 2001).

PRODUCTION

3,3'-Dimethoxybenzidine has been produced commercially since the 1920s. Data on domestic production of 3,3'-dimethoxybenzidine were last reported in 1967, when five companies produced approximately 368,000 lb (IARC 1974). Only two U.S. companies were known to produce this chemical in 1971, and only one U.S. manufacturer was listed in the Hazardous Substances Data Bank (HSDB 2001). Chem Sources (2001) listed 25 U.S. suppliers of 3,3'-dimethoxybenzidine and four suppliers of 3,3'-dimethoxybenzidine dihydrochloride. The 1979 Toxic Substances Control Act Inventory identified two companies in 1977 producing an unspecified amount of 3,3'-dimethoxybenzidine and six companies importing 55,500 lb (TSCA 1979). U.S. imports of 3,3'-dimethoxybenzidine were reported to be approximately 273,000 lb in 1971 (IARC 1974) and 106,000 lb in 1983 (USITC 1984). Imports of 3,3'-dimethoxybenzidine and its dihydrochloride salt were reported to be 655,000 lb in 1983 (USITC 1984).

EXPOSURE

The primary routes of potential human exposure to 3,3'-dimethoxybenzidine are inhalation and dermal contact. Exposure to 3,3'-dimethoxybenzidine can occur during its use as a chemical intermediate in the production of azo dyes, *o*-dianisidine diisocyanate formulations, textile processing, and packaging processes. Human exposure could occur from trace contaminants in products that are made with 3,3'-dimethoxybenzidine (e.g., azo dyes, pigments, adhesives, resins, and polyurethane elastomers). No data were found on the quantities of 3,3'-dimethoxybenzidine in consumer products.

Workers potentially exposed to the chemical include dye makers and *o*-dianisidine diisocyanate production workers. However, present dye production processes for 3,3'-dimethoxybenzidine and its dye derivatives generally are closed systems with minimal risk to workers. The National Occupational Hazard Survey, conducted by the National Institute for Occupational Safety and Health (NIOSH) from 1972 to 1974, estimated that 204 workers potentially were exposed to 3,3'-dimethoxybenzidine in the workplace (NIOSH 1976). The National Occupational Exposure Survey conducted by the National Institute for Occupational Safety and Health between 1981 and 1983 estimated that 2,482 workers potentially were exposed to 3,3'-Dimethoxybenzidine (NIOSH 1990). Another study estimated that approximately 1,000 workers were exposed to 3,3'-dimethoxybenzidine during dye manufacturing, but that as many as 15,000 workers potentially were exposed in the various dye application industries (HSDB 2001).

The U.S. Environmental Protection Agency's (EPA's) Toxic Chemical Release Inventory reported low environmental releases of 3,3'-dimethoxybenzidine and 3,3'-dimethoxybenzidine

dihydrochloride in the United States between 1988 and 1999 (TRI99 2001). Two facilities reported releases of 163 lb and 7 lb of 3,3'-dimethoxybenzidine, respectively, in 1999. One facility reported releasing 232 lb of 3,3'-dimethoxybenzidine dihydrochloride in 1999.

REGULATIONS

In 1980, the Consumer Product Safety Commission (CPSC) collected economic and toxicological data in support of a proposed ban on the use of benzidine-based dyes in direct consumer dye products. CPSC also conducted studies on the dermal penetration of two benzidine congener dyes, with negative results. The use of benzidine congener dyes in consumer products and commercial textile applications has been decreased voluntarily. Therefore, CPSC did not ban these consumer dye products. Consumer products containing benzidine congener dyes that are packaged or marketed as art and craft materials may be subject to specific procedural and labeling requirements under the Labeling of Hazardous Art Materials Act.

EPA regulates 3,3'-dimethoxybenzidine under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Resource Conservation and Recovery Act (RCRA), and Superfund Amendments and Reauthorization Act (SARA). A reportable quantity of 100 lb has been established for 3,3'-dimethoxybenzidine under CERCLA. RCRA regulates 3,3'-dimethoxybenzidine as a hazardous constituent of waste. Under SARA, 3,3'-dimethoxybenzidine is subject to reporting requirements, and general threshold quantities have been established for its use and manufacture.

NIOSH has recommended that exposure to 3,3'-dimethoxybenzidine and 3,3'-dimethoxybenzidine dihydrochloride be reduced to the lowest feasible concentration. The Occupational Safety and Health Administration regulates 3,3'-dimethoxybenzidine and 3,3'-dimethoxybenzidine dihydrochloride under the Hazard Communication Standard and as a chemical hazard in laboratories. Regulations are summarized in Volume II, Table 73.

REFERENCES

Chem Sources. Chemical Sources International, Inc., <http://www.chemsources.com>, 2001

HSDB. Hazardous Substances Data Bank. Online database produced by the National Library of Medicine. 3,3'-Dimethoxybenzidine. Profile last updated August 9, 2001. Last review date, November 7, 1991.

IARC. International Agency for Research on Cancer. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man. Some Aromatic Amines, Hydrazine and Related Substances, *N*-Nitroso Compounds and Miscellaneous Alkylating Agents. Vol. 4. Lyon, France: IARC, 1974, 286 pp.

IARC. International Agency for Research on Cancer. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Chemicals, Industrial Processes and Industries Associated with Cancer in Humans. Supplement 4. Lyon, France: IARC, 1982, 292 pp.

IARC. International Agency for Research on Cancer. IARC Monographs on the Evaluation of Carcinogenic Risks to Humans. Overall Evaluations of Carcinogenicity. Supplement 7. Lyon, France: IARC, 1987, 440 pp.

3,3'-Dimethoxybenzidine (Continued)

NIOSH. National Institute for Occupational Safety and Health. National Occupational Hazard Survey (1972-74). Cincinnati, OH: Department of Health, Education, and Welfare, 1976.

NIOSH. National Institute for Occupational Safety and Health. National Occupational Exposure Survey (NOES) (1981-1983). Unpublished provisional data as of July 1, 1990, Cincinnati OH.

NTP. National Toxicology Program. Toxicology and Carcinogenesis Studies of 3,3'-Dimethoxybenzidine Dihydrochloride (CAS No. 20325-40-0) in F344/N Rats (Drinking Water Studies). Technical Report Series TR-372. Research Triangle Park, NC: NTP, 1990.

NTP. National Toxicology Program. NTP Chemical Repository. 3,3'-Dimethoxybenzidine. Last updated August 13, 2001. (<http://ntp-server.niehs.nih.gov> and search 119-90-4).

TRI99. Toxic Chemicals Release Inventory 1999. Data contained in the Toxic Chemical Release Inventory (TRI). Available from the U.S. Environmental Protection Agency Office of Environmental Information, <http://www.epa.gov/triexplorer/reports.htm>, 2001.

TSCA. Toxic Substances Control Act, Chemical Substance Inventory, 1979: public record.

USITC. U.S. International Trade Commission. Imports of Benzenoid Chemicals and Products, 1983. USITC Publication No. 1548. Washington, DC: U.S. Government Printing Office, 1984.

**DYES METABOLIZED TO 3,3'-DIMETHOXYBENZIDINE
(3,3'-DIMETHOXYBENZIDINE DYE CLASS)**

First listed in the *Tenth Report on Carcinogens*

CARCINOGENICITY

3,3'-Dimethoxybenzidine-based dyes that are metabolized to 3,3'-dimethoxybenzidine are *reasonably anticipated to be human carcinogens* based on the fact that 3,3'-dimethoxybenzidine is carcinogenic in male and female rats (IARC 1974, NTP 1990, 1998) and that metabolism of 3,3'-dimethoxybenzidine-based dyes to release free 3,3'-dimethoxybenzidine is a generalized phenomenon that occurs in all animal species studied (Lynn *et al.* 1980, Bowman *et al.* 1983). Furthermore, a representative 3,3'-dimethoxybenzidine-based dye, C.I. Direct Blue 15, is carcinogenic in male and female rats (NTP 1992). The pattern of tumors observed with 3,3'-dimethoxybenzidine (NTP 1990) and C.I. Direct Blue 15 (NTP 1992) is similar to that observed with the structurally similar chemical 3,3'-dimethylbenzidine (NTP 1991a) and the 3,3'-dimethylbenzidine-based dye C.I. Acid Red 114 (NTP 1991b). Each of these four chemicals induces tumors of the skin, Zymbal gland, liver, oral cavity, gastrointestinal tract, preputial gland of male rats, and clitoral gland of female rats.

No adequate human studies of the relationship between exposure to 3,3'-dimethoxybenzidine-based dyes and human cancer have been reported.

OTHER INFORMATION RELATING TO CARCINOGENESIS OR POSSIBLE MECHANISMS OF CARCINOGENESIS

3,3'-Dimethoxybenzidine is structurally similar to benzidine, a *known human carcinogen* (IARC 1972, 1982, 1987, NTP 1998), and 3,3'-dimethylbenzidine, which is *reasonably anticipated to be a human carcinogen* (NTP 2000). Like benzidine and 3,3'-dimethylbenzidine, 3,3'-dimethoxybenzidine is used to synthesize many dyes, by linking of various chromophores to the base chemical by azo linkages. The azo bonds of 3,3'-dimethoxybenzidine-based dyes are chemically similar regardless of the chromophore used, and they are easily broken by chemicals or enzymes via reduction to form free 3,3'-dimethoxybenzidine and free chromophore. A number of bacteria catalyze this process, including *Escherichia coli*, found in the human gastrointestinal tract (Cerniglia *et al.* 1982, Morgan *et al.* 1994). This reductive process also has been found in rats and dogs (Lynn *et al.* 1980, Bowman *et al.* 1983). Lynn *et al.* (1980) provided quantitative evidence that the two 3,3'-dimethoxybenzidine-based dyes studied both were nearly completely metabolized to free 3,3'-dimethoxybenzidine. Bacteria in the animals' gastrointestinal tract are thought to be the primary agents of this metabolism (Cerniglia *et al.* 1982, Morgan *et al.* 1994). 3,3'-Dimethoxybenzidine-based dyes are mutagenic in bacteria when tested with metabolic activation and an azo-reductive preincubation protocol (NTP 1991a). It is assumed that the reductive breakdown process forms 3,3'-dimethoxybenzidine, which is known to cause mutations in bacteria (Haworth *et al.* 1983).

No available information suggests that mechanisms by which these substances cause cancer in laboratory animals would not also operate in humans.

PROPERTIES

3,3'-Dimethoxybenzidine, also known as *o*-dianisidine, is a colorless crystalline (sand-like) material that may turn violet upon standing. It is used in the production of dyes and is sensitive to heat, air, and, prolonged exposure to light. 3,3'-Dimethoxybenzidine is slightly soluble in water and 95% ethanol and soluble in dimethylsulfoxide, acetone, benzene, ether, and chloroform (NTP 2001). 3,3'-Dimethoxybenzidine is available commercially as the free base (technical and 99% grades) and as its dihydrochloride salt (HSDB 2001).

USE

The major use of 3,3'-dimethoxybenzidine is as an intermediate for producing 3,3'-dimethoxybenzidine-based dyes used to color leather, paper, plastic, rubber, and textiles. It also is used as a chemical intermediate in the production of 3,3'-dimethoxybenzidine diisocyanate for use in adhesives and as a component of polyurethanes. 3,3'-Dimethoxybenzidine also has been used as a test substance to detect metals, thiocyanates, and nitrites (Spectrum 1999, NTP 1990, 2001).

PRODUCTION

The U.S. International Trade Commission (USITC 1994) reported that 3,3'-dimethoxybenzidine was produced by two companies and 3,3'-dimethoxybenzidine-based dyes were produced by three companies. Current production volumes for individual producers were not reported because they are confidential for both importers and producers of 3,3'-dimethoxybenzidine. Annual U.S. production and imports of various 3,3'-dimethoxybenzidine-based dyes ranged from approximately 1,280 lb (direct blue dyes) to more than 555,000 lb (*o*-dianisidine imports) between 1978 and 1993 (USITC 1980, 1981, 1983, 1984, 1994).

EXPOSURE

Most environmental exposures to 3,3'-dimethoxybenzidine and 3,3'-dimethoxybenzidine-based dyes are through contact with contaminated air, water, or soil (HSDB 2001). The general population may be exposed via contact with paper, fabric, or leather products containing these dyes and also through consumer use of these dyes.

The primary routes of potential occupational exposure to 3,3'-dimethoxybenzidine and 3,3'-dimethoxybenzidine-based dyes are by inhalation and dermal contact. Most occupational exposures to 3,3'-dimethoxybenzidine occur in dye manufacturing and processing plants during the production of 3,3'-dimethoxybenzidine, during the use and processing of 3,3'-dimethoxybenzidine to make 3,3'-dimethoxybenzidine-based dyes, or during the application of 3,3'-dimethoxybenzidine-based dyes. In 1986 and 1987, EPA, the American Textile Manufacturers Institute, and the Toxicological Association of the Dyestuffs Manufacturing Industry conducted a joint survey to estimate airborne concentrations of dye dust in dye-weighing rooms of production plants where powdered dyes were used to dye and print textiles. Although 3,3'-dimethoxybenzidine-based dyes were not specifically included in the survey, the results are considered representative of 3,3'-dimethoxybenzidine dye dust levels. The mean airborne concentration of total dye in the 24 plants randomly monitored was estimated to be 0.085 mg/m³ (EPA 1990). However, current production processes using 3,3'-dimethoxybenzidine and 3,3'-

dimethoxybenzidine-based dyes generally are closed systems that minimize worker exposure (HSDB 2001). Occupational exposure also may occur in clinical laboratories through use of 3,3'-dimethoxybenzidine in chemical tests.

The National Occupational Exposure Survey conducted by the National Institute for Occupational Safety and Health between 1981 and 1983 estimated that 2,482 workers potentially were exposed to 3,3'-Dimethoxybenzidine (NIOSH 1990).

REGULATIONS

In 1980, the CPSC collected economic and toxicological data in support of a proposed ban on the use of benzidine-based dyes in direct consumer dye products. CPSC also conducted studies on the dermal penetration of two benzidine congener dyes, with negative results. The use of benzidine congener dyes in consumer products and commercial textile applications has been decreased voluntarily. Therefore, CPSC did not ban these consumer dye products. Consumer products containing benzidine congener dyes that are packaged or marketed as art and craft materials may be subject to specific procedural and labeling requirements under the Labeling of Hazardous Art Materials Act.

EPA regulates C.I. Direct Blue 15, a dye that is metabolized to 3,3'-dimethoxybenzidine, under the Superfund Amendments and Reauthorization Act, making it subject to reporting requirements and general threshold quantities that have been established for its use and manufacture. Regulations are summarized in Volume II, Table 73.

REFERENCES

Bowman, M.C., W.L. Oller, C.R. Nony, K.L. Rowland, and S.M. Billedeau. Metabolism and distribution of two ¹⁴C-benzidine-congener-based dyes in rats as determined by GC, HPLC, and radioassays. *J. Anal. Toxicol.*, Vol. 26, 1982, pp. 164-174.

Bowman, M.C., C.R. Nony, S.M. Billedeau, J.L. Martin, H.C.J. Thompson, and L.K. Lowry. Metabolism of 9 benzidine-congener-based azo dyes in rats based on gas chromatographic assays of the urine for potentially carcinogenic metabolites. *J. Anal. Toxicol.*, Vol. 7, 1983, pp. 55-60.

Cerniglia, C.E., J.P. Freeman, W. Franklin, and L.D. Pack. Metabolism of azo dyes derived from benzidine, 3,3'-dimethylbenzidine and 3,3'-dimethoxybenzidine to potentially carcinogenic aromatic amines by intestinal bacteria. *Carcinogenesis*, Vol. 3, 1982, pp. 1255-1260.

EPA. U.S. Environmental Protection Agency. Textile Dye Weighing Monitoring Study. EPA Report No. 560/5-90-009. Washington, DC: EPA, Office of Toxic Substances, 1990.

Haworth, S., T. Lawlor, K. Mortelmans, W. Speck, and E. Zeiger. Salmonella mutagenicity test results for 250 chemicals. *Environ. Mutagen.*, Vol. 5, 1983, pp. 3-142.

HSDB. Hazardous Substances Data Bank. Online database produced by the National Library of Medicine. 3,3'-Dimethoxybenzidine. Profile last updated May 15, 2001. Last revision date, November 7, 1991.

IARC. International Agency for Research on Cancer. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans Some Inorganic Substances, Chlorinated Hydrocarbons, Aromatic Amines, *N*-Nitroso Compounds, and Natural Products. Vol. 1. Lyon, France: IARC, 1972, pp. 87-91.

IARC. International Agency for Research on Cancer. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans Some Aromatic Amines, Hydrazine and Related Substances, *N*-Nitroso Compounds and Miscellaneous Alkylating Agents. Vol. 4. Lyon, France: IARC, 1974, pp. 41-47.

IARC. International Agency for Research on Cancer. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans. Some Industrial Chemicals and Dyestuffs. Vol 29. Lyon, France: IARC, 1982, 149 pp.

IARC. International Agency for Research on Cancer. IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans Overall Evaluations of Carcinogenicity: An Updating of IARC Monographs. Suppl 7. Lyon, France: IARC, 1987, pp. 198-199.

Lynn, R.K., D.W. Donielson, A.M. Ilias, J.M. Kennish, K. Wong, and H.B. Matthews. Metabolism of bisazobiphenyl dyes derived from benzidine, 3,3'-dimethylbenzidine or 3,3'-dimethoxybenzidine to carcinogenic aromatic amines in the dog and rat. *Toxicol. Appl. Pharmacol.*, Vol., 56, 1980, pp. 248-258.

Morgan, D.L., J.K. Dunnick, T. Goehl, M.P. Jokinen, H.B. Matthews, E. Zeiger, and J.H. Mennear. (1994). Summary of the National Toxicology Program Benzidine Dye Initiative. *Environ. Health. Perspect.*, Vol. 102, 1994, pp. 63-78.

NIOSH. National Institute for Occupational Safety and Health. National Occupational Exposure Survey (NOES) (1981-1983). Unpublished provisional data as of July 1, 1990, Cincinnati OH

NTP. National Toxicology Program. Toxicology and Carcinogenesis Studies of 3,3'-Dimethoxybenzidine Dihydrochloride in F344/N Rats (Drinking Water Studies). Technical Report Series TR-372. Research Triangle Park, NC: NTP, 1990, 70 pp.

NTP. National Toxicology Program. Toxicology and Carcinogenesis Studies of C.I. Acid Red 114 (CAS No. 6459-94-5) in F344/N Rats (Drinking Water Studies). Technical Report Series TR-405. Research Triangle Park, NC: NTP, 1991a.

NTP. National Toxicology Program. Toxicology and Carcinogenesis Studies of 3,3'-Dimethylbenzidine Dihydrochloride in F344/N Rats (Drinking Water Studies). Technical Report Series TR-390, 1991b. Research Triangle Park, NC: NTP, 231 pp.

NTP. National Toxicology Program. Toxicology and Carcinogenesis Studies of C.I. Direct Blue 15 in F344/N Rats. Technical Report Series TR-397. Research Triangle Park, NC: NTP, 1992, 249 pp.

NTP. National Toxicology Program. Ninth Report on Carcinogens, 2000. <http://ehp.niehs.nih.gov/roc/toc9.html>.

NTP. National Toxicology Program. NTP Chemical Repository. 3,3'-Dimethoxybenzidine. Last updated August 13, 2001. (<http://ntp-server.niehs.nih.gov> and search 119-90-4).

Spectrum. 3,3'-Dimethoxybenzidine, 1999.
<http://www.speclab.com/compound/c119904.htm>.

USITC. U.S. International Trade Commission. Synthetic Organic Chemicals. United States Production and Sales, 1979. Publication No. 1099. Washington, DC: U.S. Government Printing Office, 1980.

USITC. U.S. International Trade Commission. Synthetic Organic Chemicals. United States Production and Sales, 1980. Washington, DC: U.S. Government Printing Office, 1981.

USITC. U.S. International Trade Commission. Synthetic Organic Chemicals. United States Production and Sales, 1982. Washington, DC: U.S. Government Printing Office, 1983.

USITC. U.S. International Trade Commission. Synthetic Organic Chemicals. United States Production and Sales, 1983. Publication No. 1588. Washington, DC: U.S. Government Printing Office, 1984.

USITC. U.S. International Trade Commission. Synthetic Organic Chemicals. United States Production and Sales, 1993. Publication No. 2933. Washington, DC: U.S. Government Printing Office, 1994.